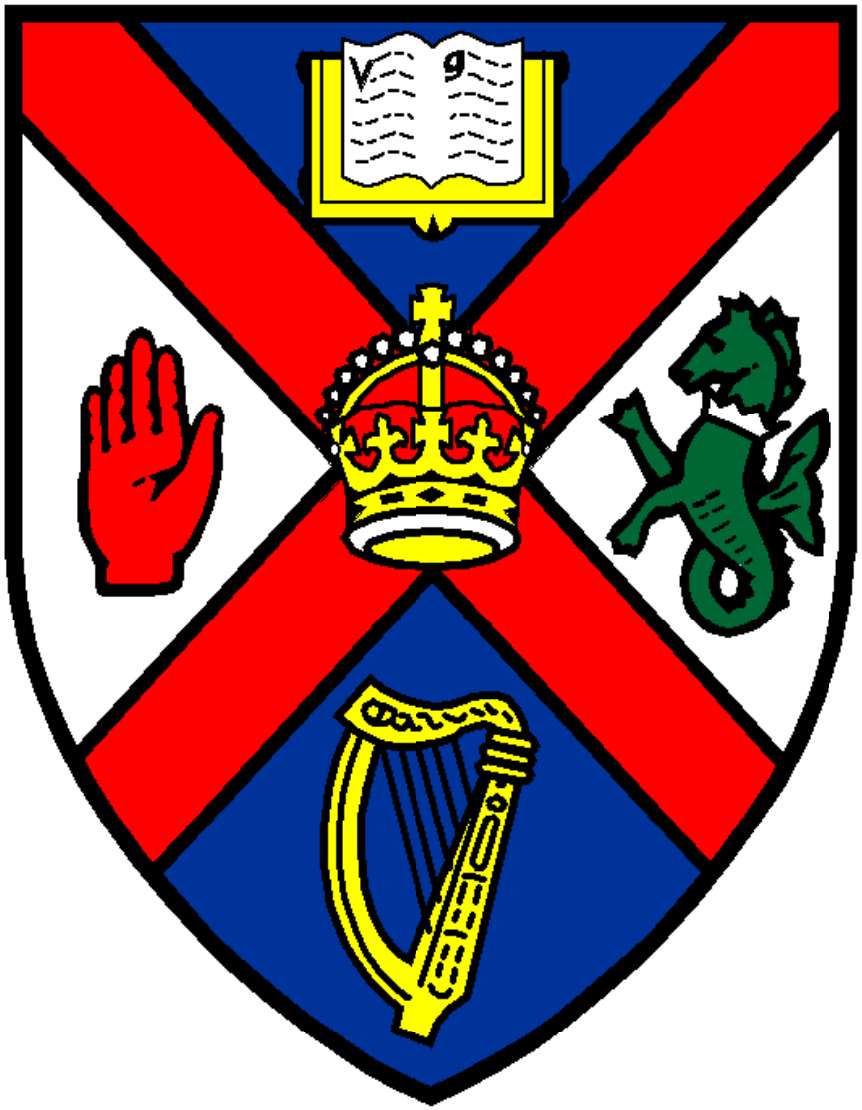
Design optimisation of steel portal frames

Queen's University
Belfast

Queen’s University Belfast

Crest; Coat of Arms; Emblem



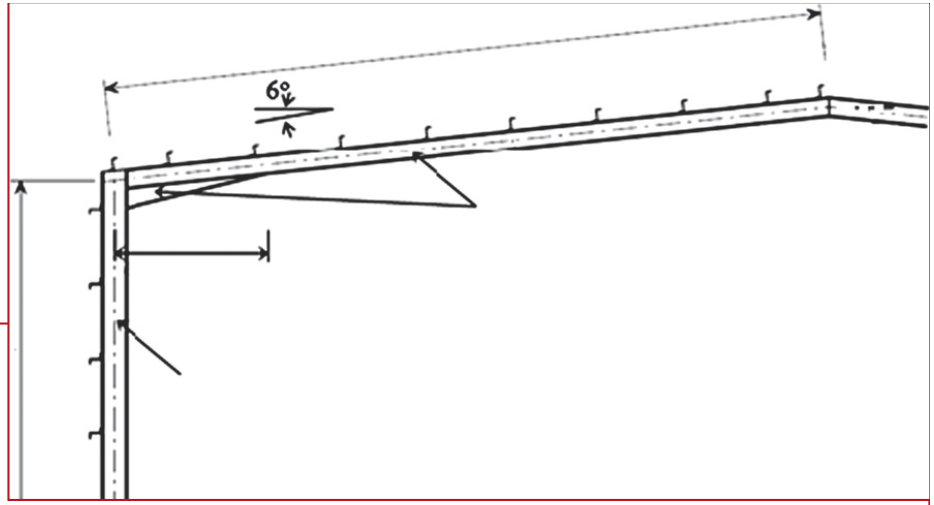
Queen’s University Belfast
Lanyon Building

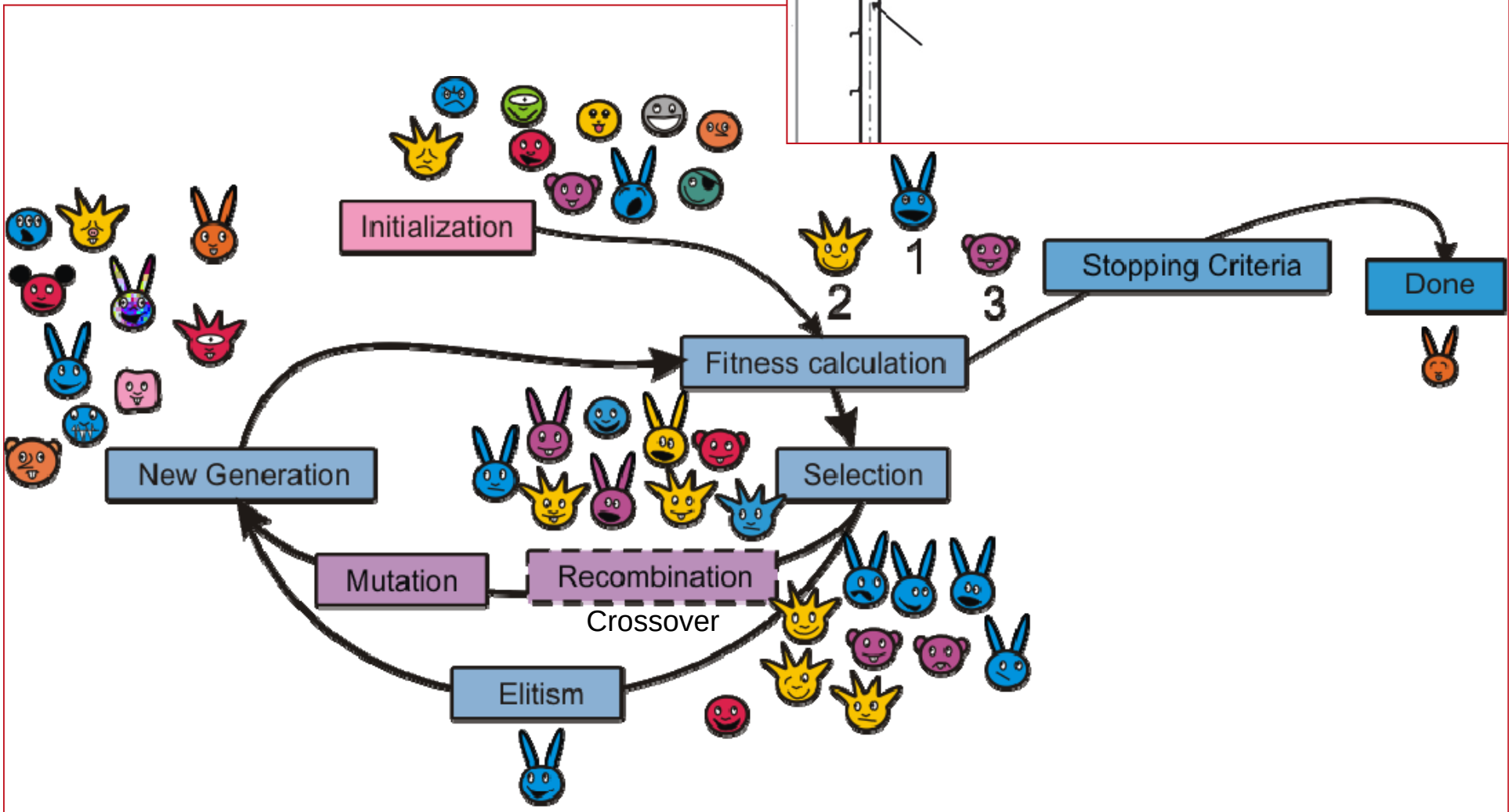
Design optimisation of steel portal frames

Wei Sha
School of Planning, Architecture and Civil Engineering
Queen's University Belfast

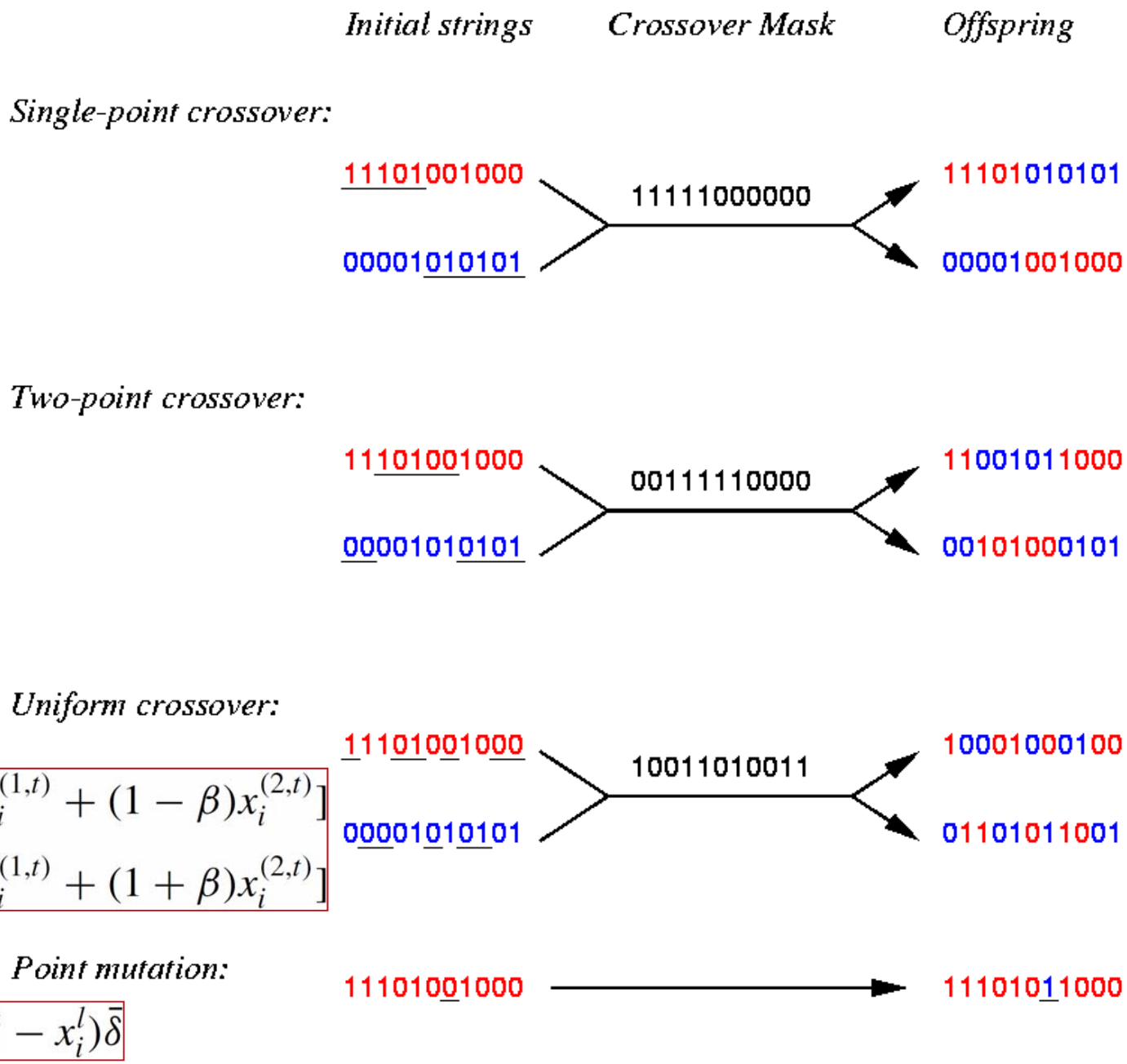
Google Images “steel portal frame buildings uk”

Genetic algorithm





Journal of Constructional Steel Research, **86**, 2013, 74-84.

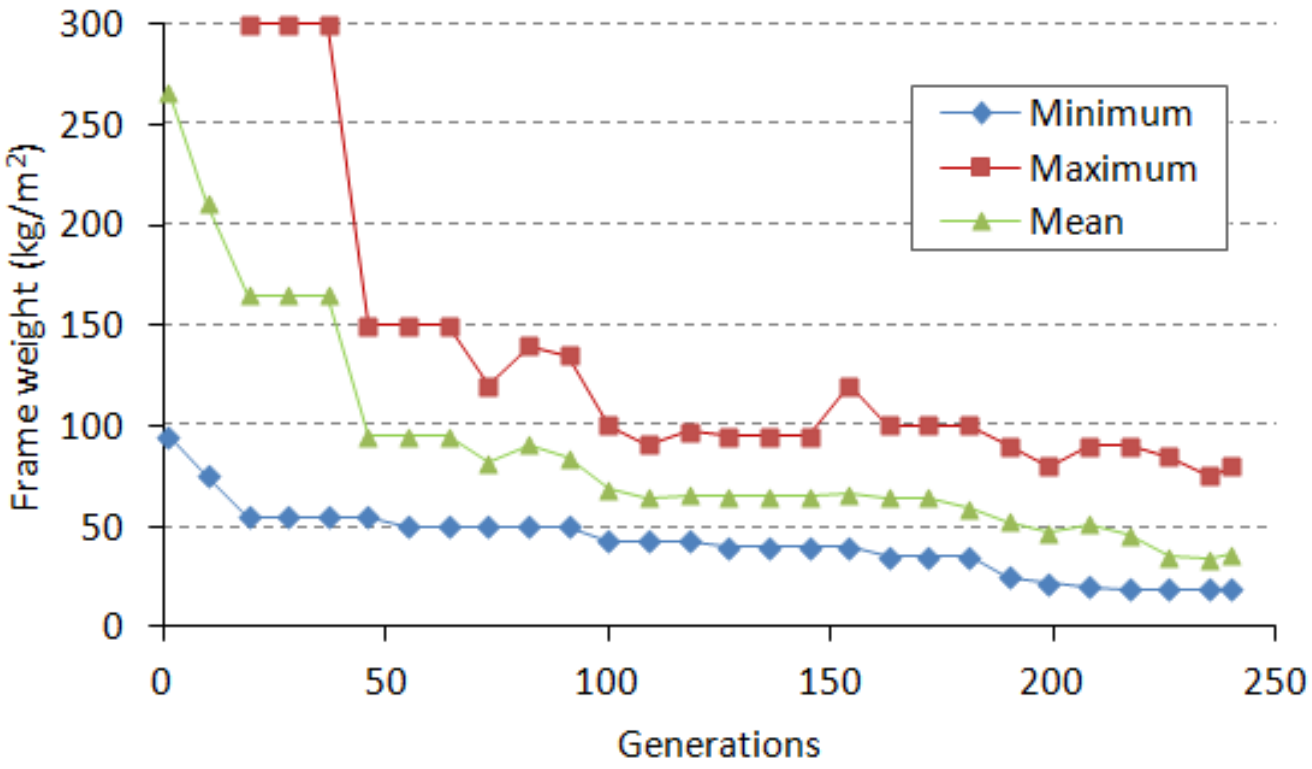


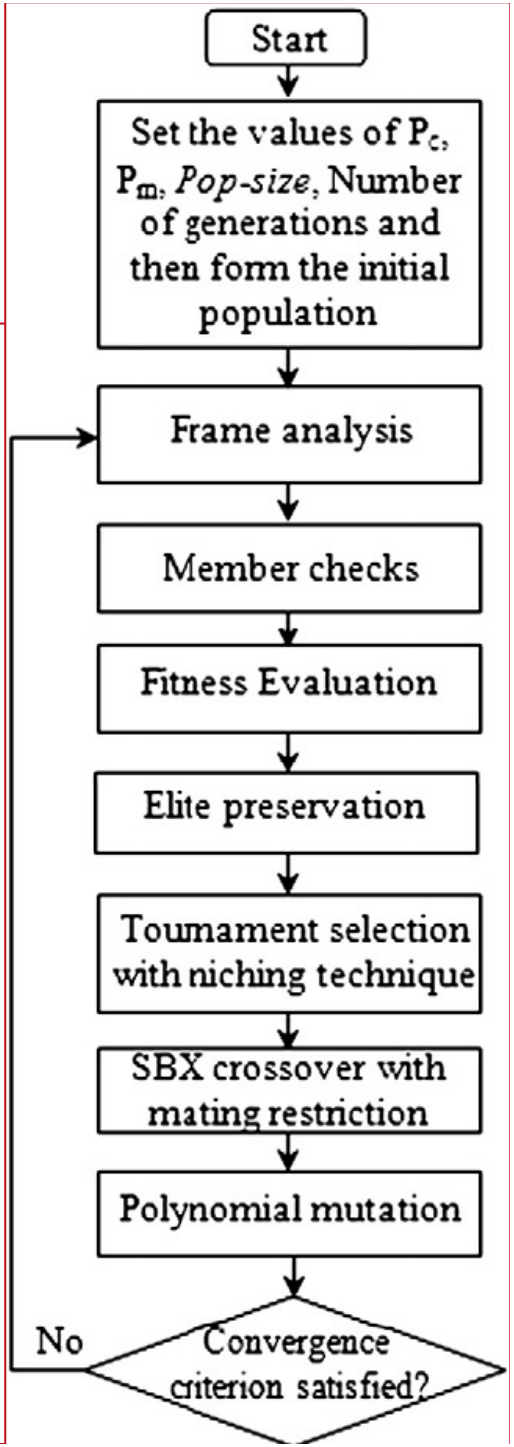
$$x_i^{(1,t+1)} = 0.5[(1+\beta)x_i^{(1,t)} + (1-\beta)x_i^{(2,t)}]$$
$$x_i^{(2,t+1)} = 0.5[(1-\beta)x_i^{(1,t)} + (1+\beta)x_i^{(2,t)}]$$

$$y_i^{(1,t+1)} = x_i^{(1,t+1)} + (x_i^u - x_i^l)\bar{\delta}$$

Engineering Optimization, **45**, 2013, 415-33.

Flowchart and convergence





Twenty-First International Specialty Conference on Cold-Formed Steel Structures, 2012, 485-97.

Topography optimisation

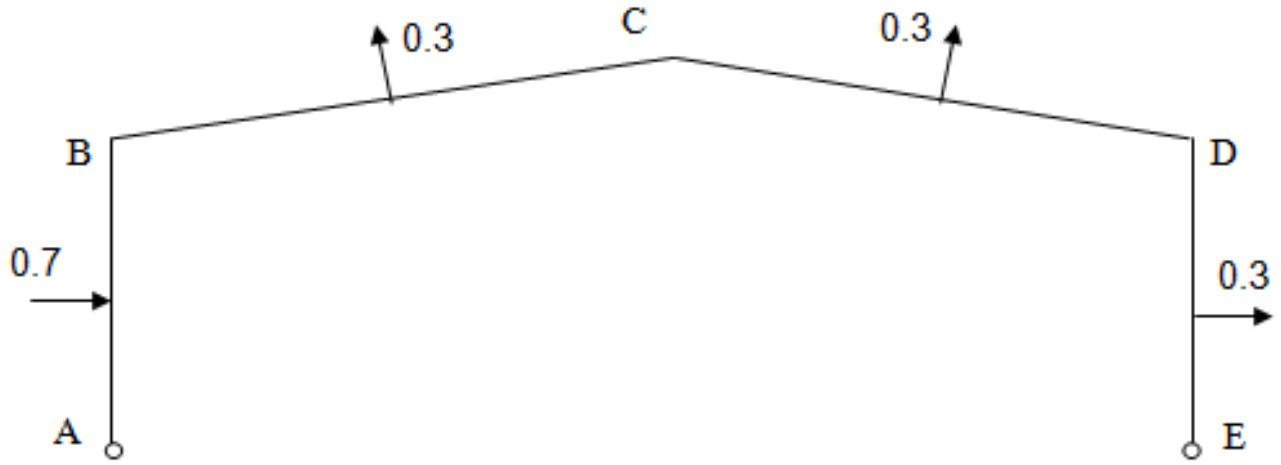
1: Geometries and section sizes for three exemplar frames 10°, 4 m

Frame	Span (m)	Height (m)	Section sizes for unit weight (kg/m)			Section sizes for unit cost (AUD/m)		
			Column section	Rafter section	Unit weight	Column section	Rafter section	Unit cost
A	15	3	BBC30030	BBC30030	135.46	BBC30030	BBC30030	384.82
B	20	4	BBC30030	BBC30030	180.60	BBC30030	BBC30030	513.34
C	25	5	BBC35030	BBC35030	269.46	BBC35030	BBC35030	791.60

2: The result of optimum solutions for three exemplar frames

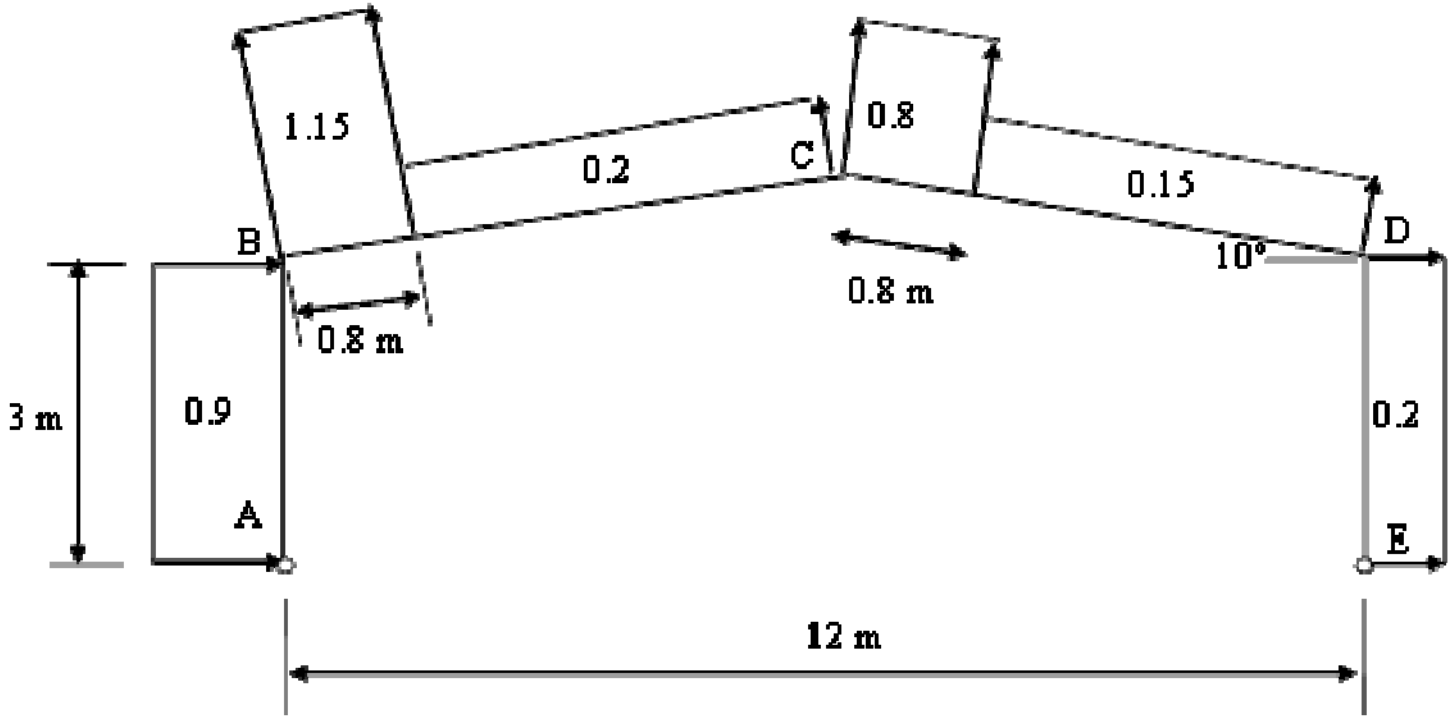
Frame	Span (m)	Height (m)	Pitch (degree)	Bay spacing (m)	Wind pressure (kN/m^2)	Column sections	Rafter sections	Unit cost (AUD/m)
A	15	3	21	3.17	1.45	BBC25024	BBC25024	248.19
B	20	4	21	2.95	0.91	BBC25024	BBC25024	355.60
C	25	5	20.9	2.16	0.68	BBC25024	BBC25024	606.80

Procedia Engineering, **14**, 2011, 724-33.



Australian coefficients of wind pressure for wind load combination 1.

8 combinations.



British coefficients of wind pressure for wind load combination 1.

6 combinations.

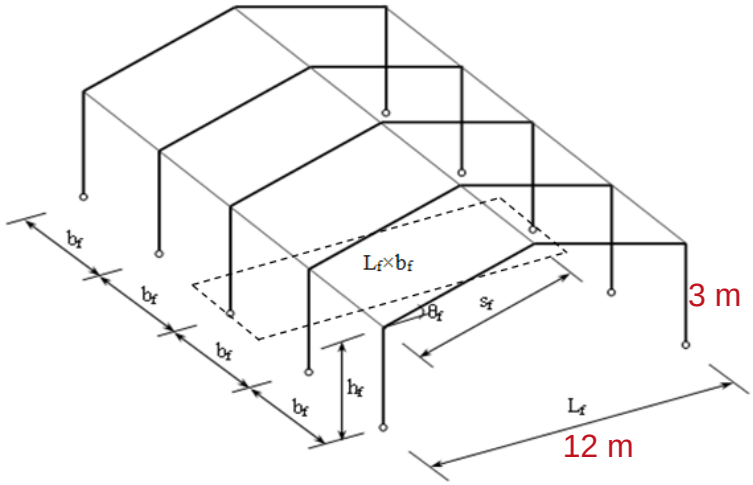
Steel and Composite Structures, **15**, 2013, 519-38.

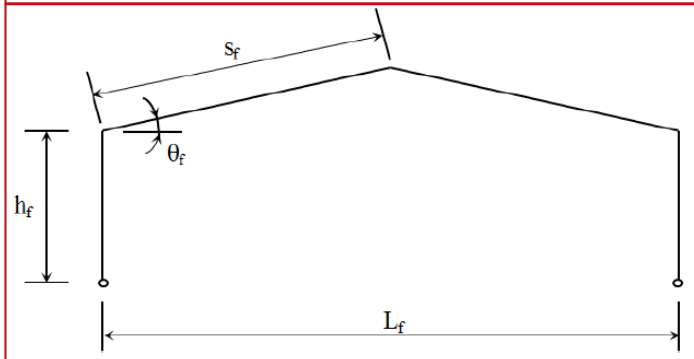
Cost
Hot or cold?

Table 9 Cost of Reference Frame

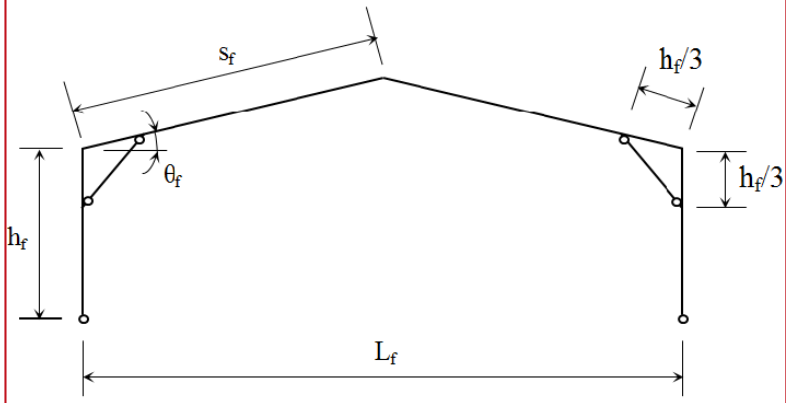
Type	Topology	Main frame (£/m^2)
Hot-rolled steel	Fixed	6.60
Type 1	Fixed	6.59
Type 1	Variable	5.60
Type 2	Fixed	6.20
Type 2	Variable	4.70

Thin-Walled Structures, under review.



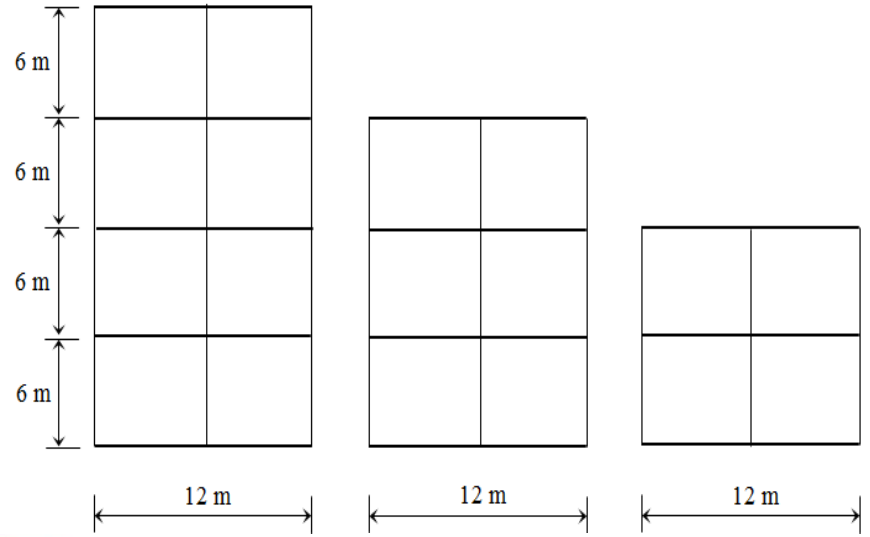


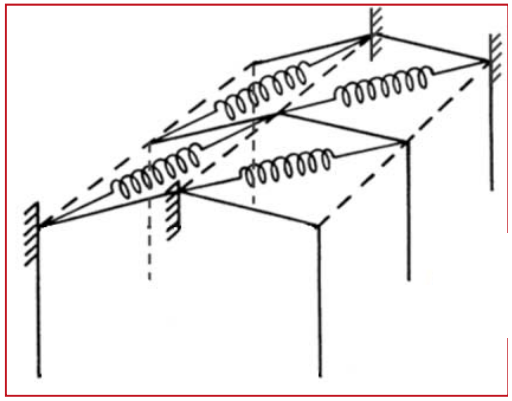
(a) Type 1: Rigid-jointed frame

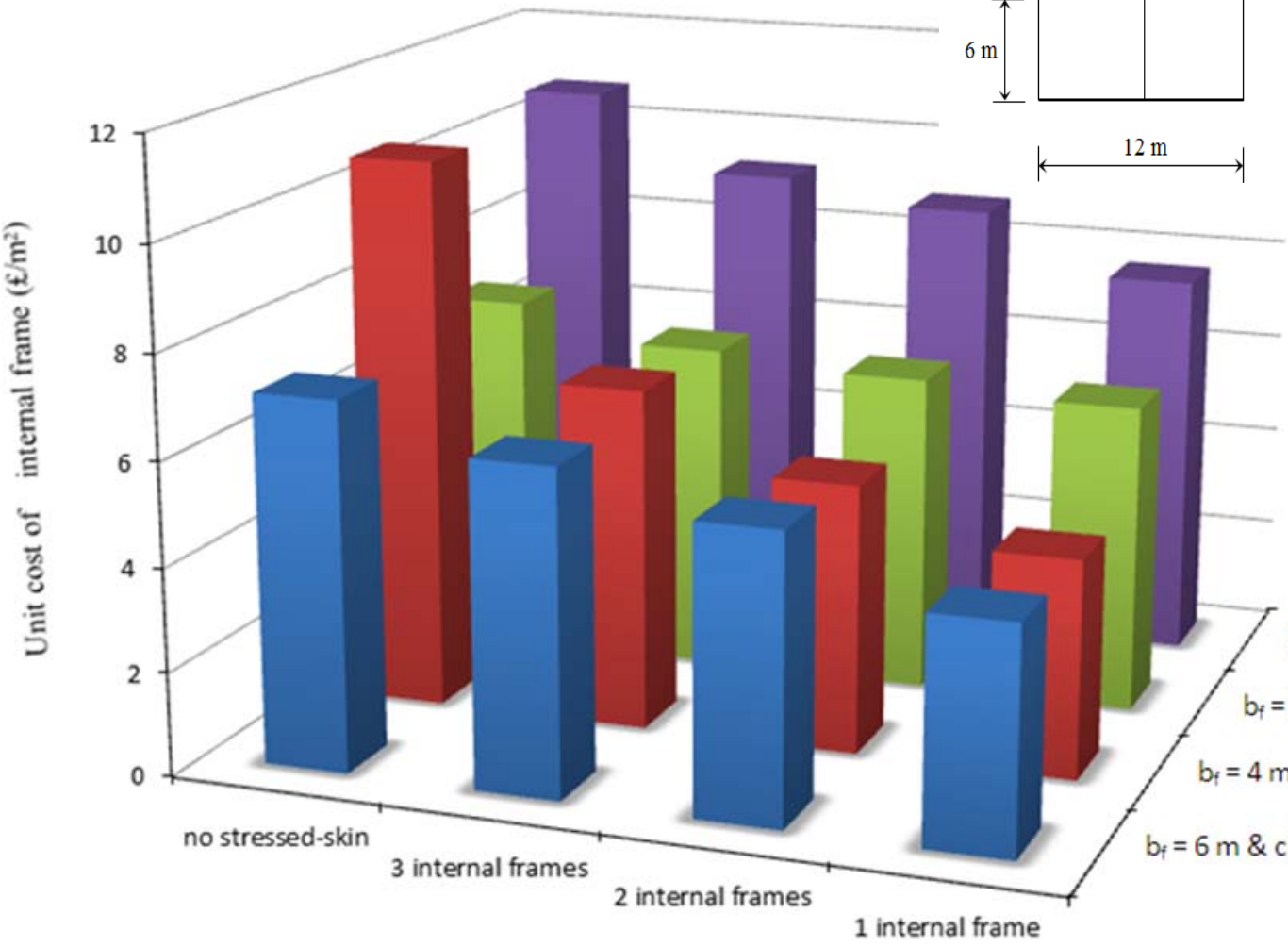


(b) Type 2: Rigid-jointed frame having knee braces at the eaves

Stressed-skin
Cost of internal frames

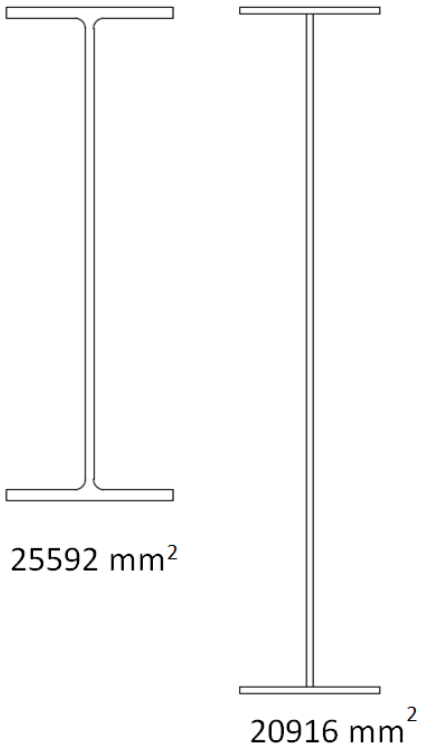


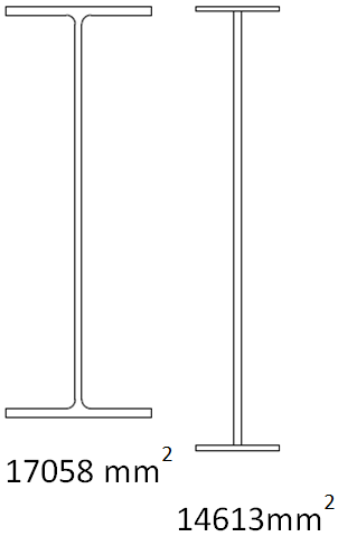




PhD thesis: Duoc Phan. KTP with Capital Steel Buildings

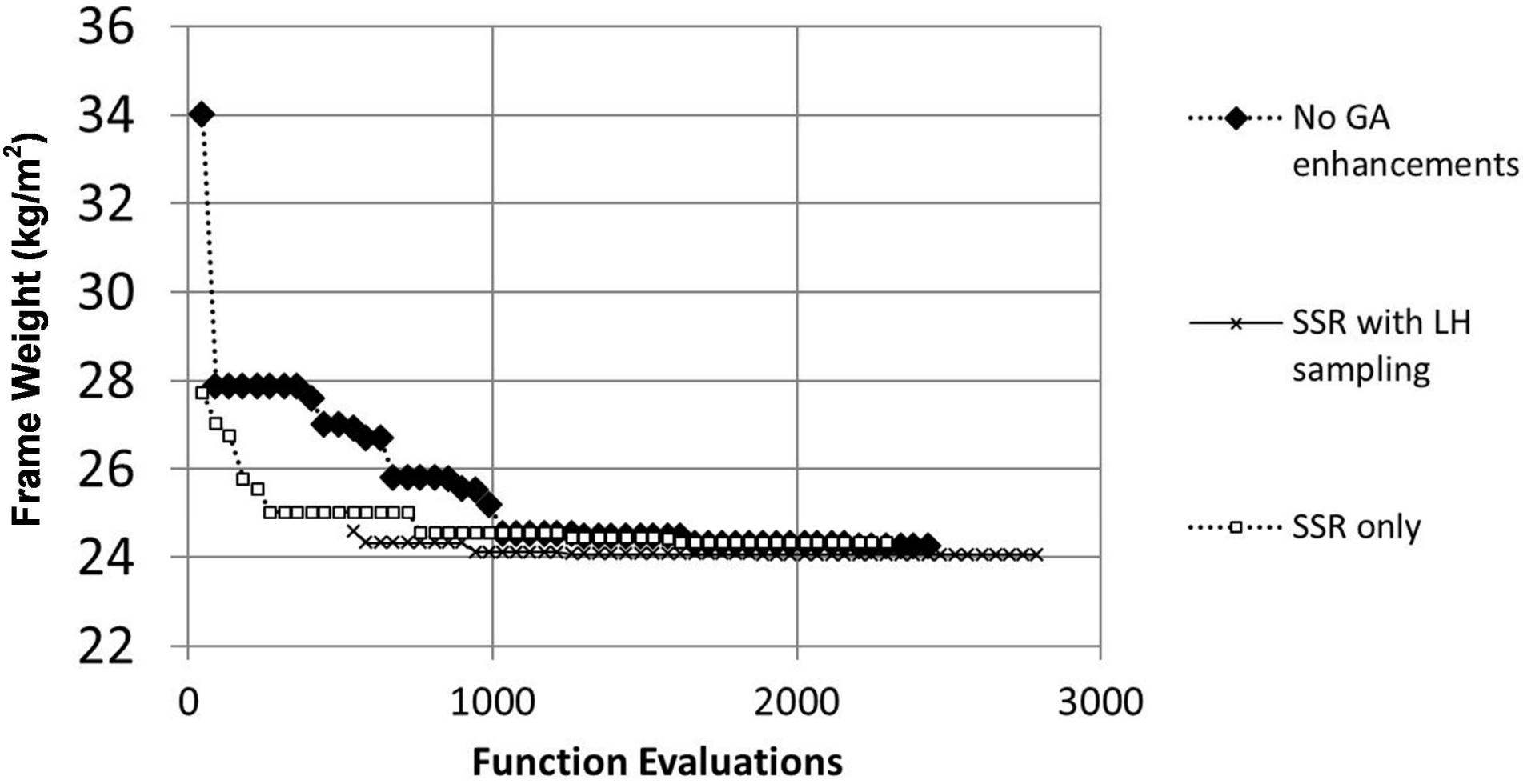
Optimal design of long-span steel portal frames using fabricated beams to Eurocode 3





Column Rafter 35% saving

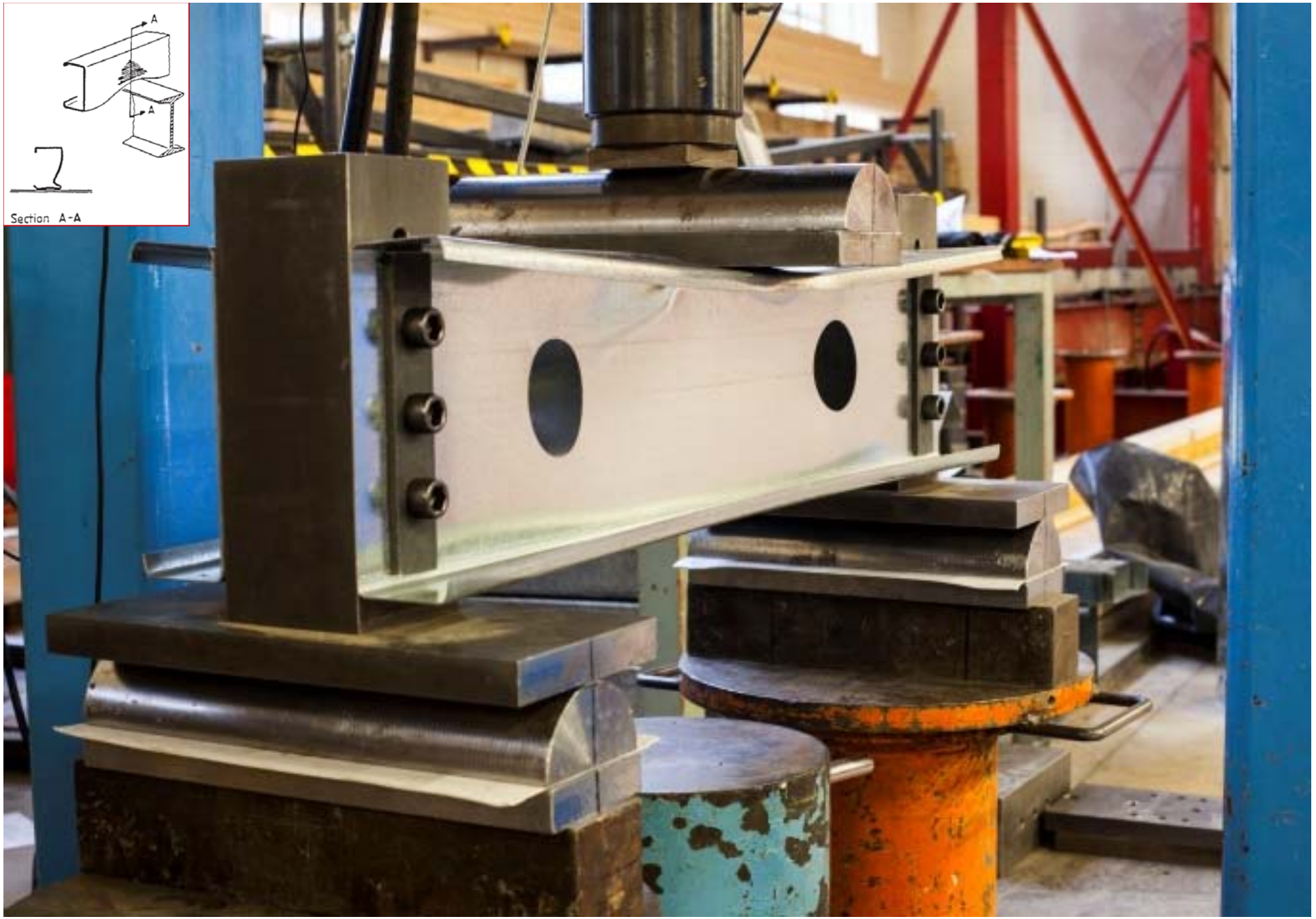
Journal of Constructional Steel Research, under review.



Search space reduction (SSR): eliminating sections with significantly lower moment capacities. Reduced from 80 to 30.

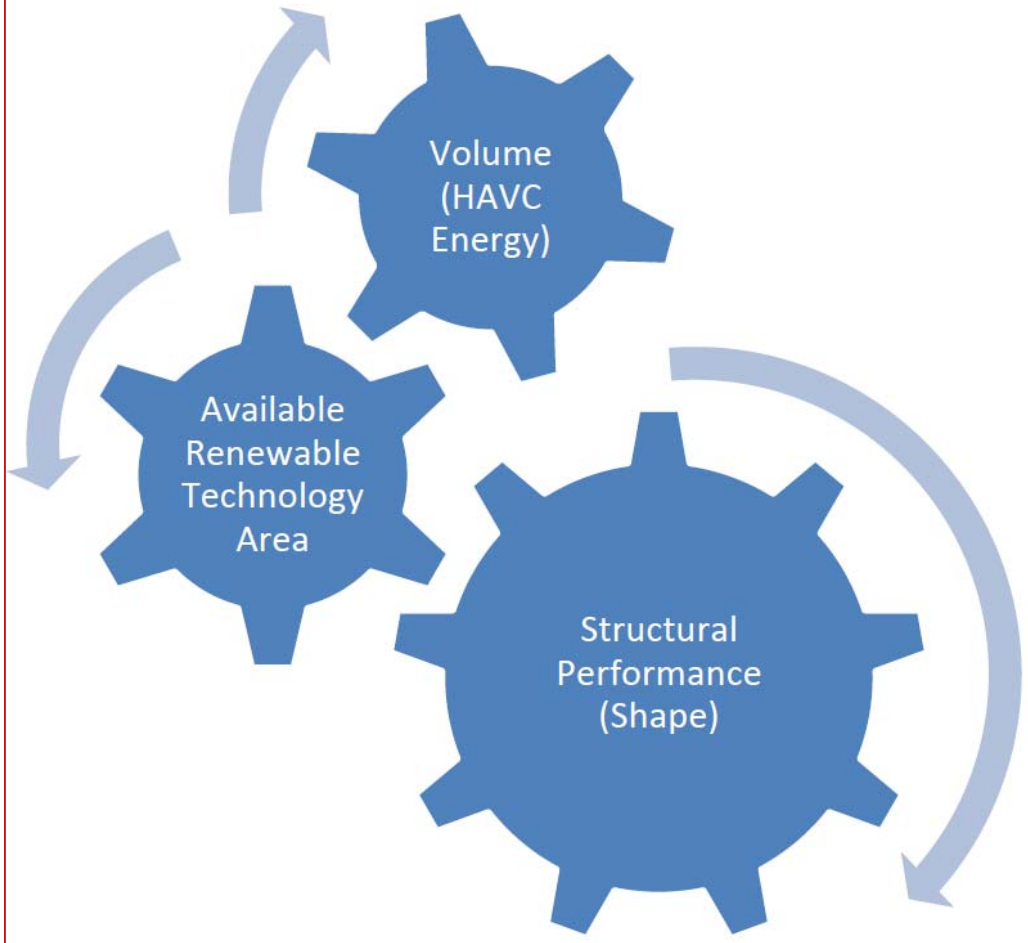
Latin hypercube (LH) sampling plan: larger initial population was ranked based on fitness value.

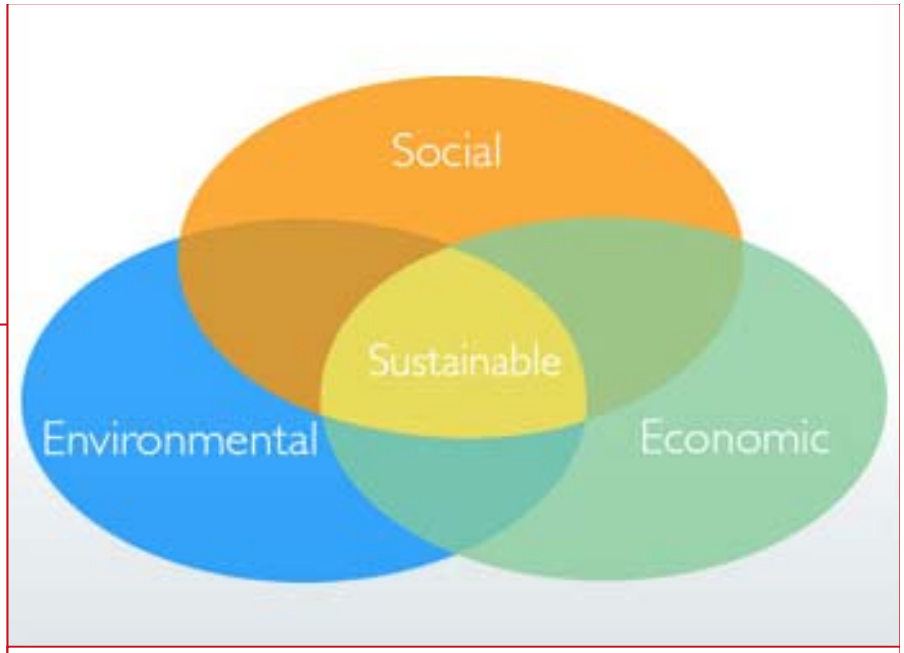
Journal of Constructional Steel Research, under review.

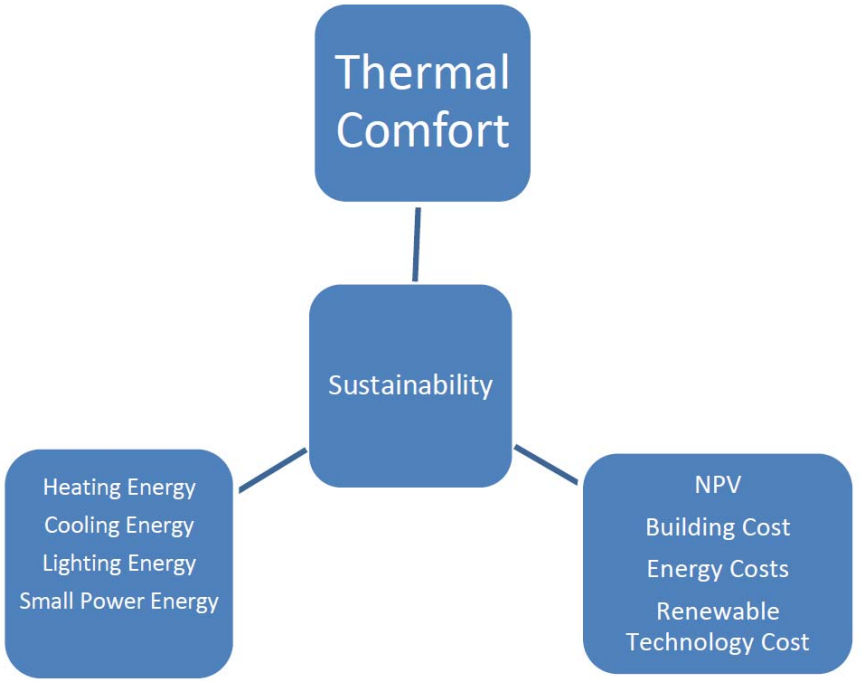


PhD student: Ying Lian

Potential GA objectives





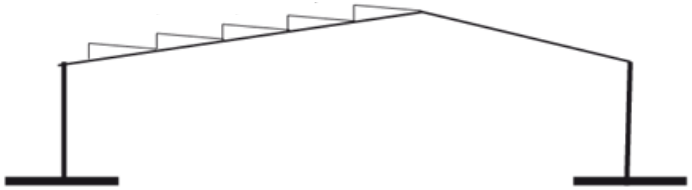


PhD student: Ross McKinstray. KTP with Ostick+Williams

Design options

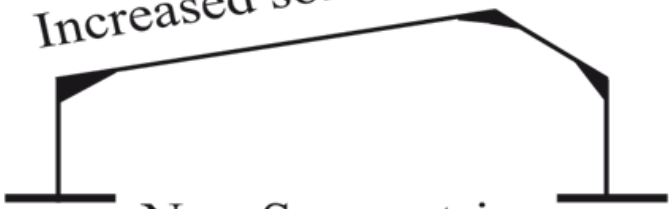
Symmetric portal frame

Truss Portal

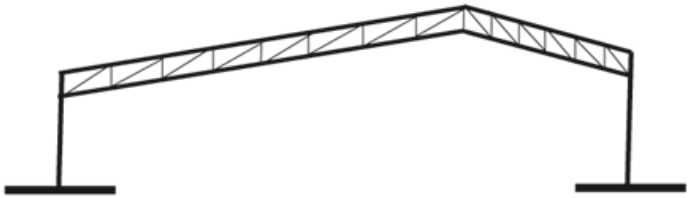


North Lights

Increased solar gain



Non-Symmetric
portal frame



Non-Symmetric
Truss Portal

PhD student: Ross McKinstray

Wei Sha

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